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CAINOZOIC SEDIMENTATION IN THE MURRAY DRAINAGE BASIN, NEW SOUTH WALES SECTION

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ABSTRACT: Geological evolution of the drainage basin began in Eocene time with commencement of sedimentation in the Murray Basin. The initial phase consisted of widespread deposition under terrestrial conditions, including some sedimentation of embayments in the valley margin which appear to mark the location of the forerunners of the Murrumbidgee and Lachlan Rivers. During a marine transgression from the southwest, which persisted from Oligocene to Pliocene time, terrestrial deposition was restricted to the eastern marginal parts of the Basin. Erosion of the present Murrumbidgee and Lachlan valleys in the eastern highlands occurred mainly during late Pliocene and Pleistocene time. The history of the Murray Valley upstream from Corowa is similar to that of the Lachlan and Murrumbidgee, but it joined a northward extension of the Ovens River prior to the late Pleistocene when it linked with the Goulburn River drainage system. Sand and gravel lenses within some of the Tertiary formations constitute an important aquifer system, from which can be obtained supplies of low salinity water sufficient for irrigation and municipal purposes.

INTRODUCTION

The area referred to in this paper includes the drainage basins of the Lachlan and Murrumbidgee Rivers, and the N.S.W. part of the Murray and Lower Murray drainage basins, as defined by the Australian Water Resources Council (1976). Aspects of the Cainozoic geology within other parts of the Murray-Darling System are described by Taylor (1978) who refers to the Darling drainage basin, and Macumber (1978) who describes the Victorian part of the Murray drainage basin.

Much of the new information on which conclusions in this paper are based has been obtained as a result of investigations into groundwater resources of the area by the Water Resources Commission of N.S.W. The Tertiary sequence contains several very important aquifers, and groundwater within the study area is of economic importance both as a source of water for irrigation and municipal water supplies and because of its effects on surface hydrology. A brief statement on groundwater occurrence has therefore been incorporated.

The geological evolution of the Murray-Darling drainage system can be regarded as having commenced in early Tertiary time with the beginning of deposition of sediments in the Murray Basin. This structure is a sedimentary basin of some 300,000 km^2 extent in Victoria, New South Wales and South Australia. Of this 135,000 km^2 are in N.S.W. It was initiated by movement along major lineaments and fracture zones during Early Permian and to a lesser extent Jurassic-Early Cretaceous time (Scheibner 1974), and subsidence continued during the Cainozoic while active sedimentation was taking place (Pels 1969). At the commencement of Tertiary sedimentation, the land surface consisted of Palaeozoic rocks around the margins, with Palaeozoic, Permian, Cretaceous and Triassic units exposed in the Basin floor area. Contours on this pre-Tertiary surface are shown in Fig. 1. The Tertiary stratigraphy of the New South Wales part of the Basin has been described by Woolley and Williams (1977), and is summarised by the cross section in Fig. 2.

CAINOZOIC GEOLOGY AND STRATIGRAPHY

The first phase of sedimentation in N.S.W. is represented by the mid- to late-Eocene Warina Sand (Lawrence 1972) which was deposited under generally non-marine conditions, and consists of medium to coarse grained quartz sand with minor dark grey clay lenses and carbonaceous layers. It is restricted to the deepest parts of the Basin, and in New South Wales does not occur east of Hay. The

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overlying unit is the Olney Formation (Lawrence 1972) which was deposited under deltaic, fluvial, lagoonal and tidal-flat environments, and is dominated by lignite layers up to several tens of metres thick. It also contains grey carbonaceous clay and extensive sand lenses, and occurs throughout the Basin. In the southwestern part of N.S.W. its age is late Eocene, but in the eastern part of the Basin it ranges up to early Miocene. These ages, and most others quoted below, are based on the palynological studies of Martin (1973, 1977, pers. com.).

Sediments of Eocene age which can be referred to the Olney Formation occur in a narrow valley for a few km upstream from the margin of the Murray Basin at Narrandera. This long narrow embayment into the highland area flanking the Eocene plain is the earliest recognisable stage of the Murrumbidgee River system. A similar embayment appears to have been present east of Hillston representing the earliest stage of the Lachlan River, but dating of the deposits in this locality is less certain. There is no known comparable feature related to the Murray River which did not adopt its present course until much later, but similar features have been noted by Macumber (op. cit.), notably for the Goulburn River.

During early Oligocene time a marine transgression commenced from the southwest and resulted in deposition of the Ettrick Marl above the Olney Formation in southwestern N.S.W. This grades to the east into a glauconitic and dolomitic clay (Geera Clay, Lawrence 1966) which in turn grades laterally into the middle parts of the Olney Formation. The Olney Formation represents terrestrial deposition around the Basin margin, concurrent with marine deposition in the shallow sea to the west.

The area subject to marine conditions reached a maximum during Miocene time, but the sea did not extend much further east than Balranald. From early to mid-Miocene the Duddo Limestone was deposited in the southwest of N.S.W., with its landward equivalent the Winnambool Formation. The latter is represented by siltstone, sandy clay and dolomite in N.S.W. and grades to the east (landward) into the upper part of the Olney Formation, its terrestrial equivalent. There was a period of non-deposition in the eastern part of the Basin during the mid-Miocene and presumably a slight regression of the sea, but marine deposition was continuous. Rivers draining the highlands to the east and north of the Basin and the swampy areas bounding the Miocene sea were the forebears of the present Murray-Darling System.

There is some depositional evidence of a river system in the highland area dating from this time and valley erosion is assumed to have been more or less continuous until the late Oligocene (Wellman & McDougall 1974). The embayments at Hillston and Narrandera persisted from Eocene time, but there is a long gap between the upstream limit of Miocene sedimentation in them, and comparable material in the main highlands. The high level Glen Logan Gravel which occurs within the present Lachlan Valley around Cowra is considered to be of Miocene age (Williamson 1964) and represents the earliest phase of deposition in the highland part of that valley. More definite dating is available for early Miocene fluvial and lacustrine deposits up to 300 m thick in the Snowy Mountain area (Owen 1975), and for early Pliocene basalt which partly infills valleys in the same area and overlies the lacustrine material (Wellman & McDougall op. cit.). Some of these localities are within the present Murray/Murrumbidgee drainage system, but their relationship to the drainage system of the early Miocene is not clear. Climate of the time was warm and humid, with an annual rainfall of 1500-1800 mm near Wagga Wagga (Martin 1977) slightly less than during the Oligocene when the annual rainfall is estimated to have exceeded 1800 mm (Martin op. cit.).

Terrestrial deposition around the Basin margin recommenced in the late Miocene with deposition of the Calivil Formation (Macumber 1973) which continued until early Pliocene time. This formation is dominated by coarse quartz sand and gravel, particularly in the Basin margin areas. It represents the initial phase of erosion associated with the post mid-Miocene uplift of 200 m (Wellman & McDougall op. cit.) which can be identified with the Kosciusko uplift (Browne 1969). The proportion of clay increases towards the centre of the Basin. It grades into and partly overlies the Bookpurnong Beds, which consist of pyritic siltstone and sandstone grading westwards to glauconitic sand deposited during the final phase of marine transgression. The coarse grain size of the Calivil Formation probably reflects the first movements of the Kosciusko Uplift, during which the present valleys of the Murrumbidgee, Lachlan, and Murray Rivers were further entrenched into the Palaeozoic terrain to the north and east of the Murray Basin.

At this stage, there was still no Murray River as we now know it. The river draining the Murray

Valley of the eastern highlands left its present course just north of Corowa and flowed in a west-northwesterly direction to join with the north-flowing Ovens River. This drainage system is indicated by the distribution of alluvial deposits upstream of Corowa and by bedrock contours in the Ovens Valley shown by Macumber (1978, Fig. 1). Additional evidence is provided by bedrock contours north of the Murray River and west of Corowa (Fig. 1), and by the apparent absence of sediments older than Pleistocene in the shallow alluvial-filled gap at Mulwala (midway between Tocumwal and Corowa, Fig. 1).

In Pliocene time, rainfall began to increase (Martin 1973) and final regression of the sea had commenced, resulting in deposition of shoreline deposits of the Parilla Sand. Terrestrial deposition around the eastern margin of the Basin was mainly fluvial and comprised the silt, clay, and minor sand of the Shepparton Formation (Lawrence 1975). Aggradation of the eroded valleys of the Murrumbidgee, Lachlan and Murray Rivers, and probably also of the Darling, commenced. These sediments, referred to the Lachlan Formation (Williamson 1964), are dominated by pale grey quartz gravels and grey clays which may be carbonaceous. Rainforest was widespread at this time, particularly in the eastern part of the drainage system.There was apparently a decrease in annual rainfall from the eastern highlands to the west, with over 1800 mm at Wagga Wagga and less than 1500 mm at Hay (Martin 1973).

During the Pleistocene Period, rainfall decreased substantially, to the extent that the rainforest disappeared from much of the catchment. This correlates with, and may have been an important causal factor of, a change in the type of sediment supplied to the river system as erosion progressed rapidly without the protective forest vegetation. Polymictic gravels, generally quite coarse, are widespread in the shallower parts of the alluvial fill of the main valley systems deposited under this regime (Kalf & Woolley 1977). They are interbedded with brown fluvial clay and sandy clay deposits, in a depositional unit referred to as the Cowra Formation (Williamson 1964).

West of the highlands, the present Riverine Plain was formed during this period by the action of distributory and aggrading prior streams (Butler 1950). The prior stream sands are the plains equivalent of the gravels of the Cowra Formation.

It seems likely that a major change in the Murray-Ovens-Goulburn drainage system took place during late Pleistocene time. The north-flowing Ovens, joined near Corowa by the Murray, changed its course to flow west and link with the Goulburn. This initiated the present day Murray River System as 'a westerly flowing connector linking the northerly and northwesterly flowing (Victorian) tributary systems' (Macumber 1978). Subsequent evolution of this river system is beyond the scope of this paper but has been examined by a number of authors (e.g. Pels 1966).

OCCURRENCE OF GROUNDWATER

Groundwater occurs extensively within the Cainozoic sediments, and the following formations are particularly favourable:

Warina Sand: This is the basal stratigraphic unit within the Cainozoic sequence, and does not occur east of the latitude of Hay. It is an important source of water for stock, but except in a small area near the eastern limit of its extent the salinity of its water exceeds 1000 mg/l which is unsuitable for irrigation or municipal uses. Water salinity increases towards the west, to about 4000 mg/l near Balranald and higher west of there. The formation has a high transmissivity (400-2000 m^2/d from limited tests), indicating that high yields would be available.

Olney Formation: This unit contains extensive sand and gravel lenses, particularly in the alluvial fan area west of Narrandera (located near Bore 25394, Fig. 1) where they are coarse grained and thick. Very high transmissivity values (800-6000 m^2/d) have been obtained in this area, where a number of high yielding (100 to 300 l/s) bores are used for irrigation. The usefulness of the aquifer decreases towards the west because of increasing water salinity and a smaller proportion of sand and gravel lenses within the formation. Water having a salinity of less than 1000 mg/l occurs within a zone between the Lachlan River and Willandra Creek, with a western limit at about the latitude of Booligal, and also in a zone mainly south of the Murrumbidgee River extending west nearly to Hay. There is a further zone between Tocumwal and Deniliquin, less well delineated, in which the aquifers also contain low salinity water. West of these areas the salinity increases rapidly (10,000 mg/l at Balranald).

Calivil Formation: The major water-bearing sand and gravel lenses in this Formation are also located in the alluvial fan west of Narrandera, where high yielding bores used for irrigation obtain part or all of their supply from them. The distribution of water salinity within the unit is comparable to that in the Olney Formation, but the sand and

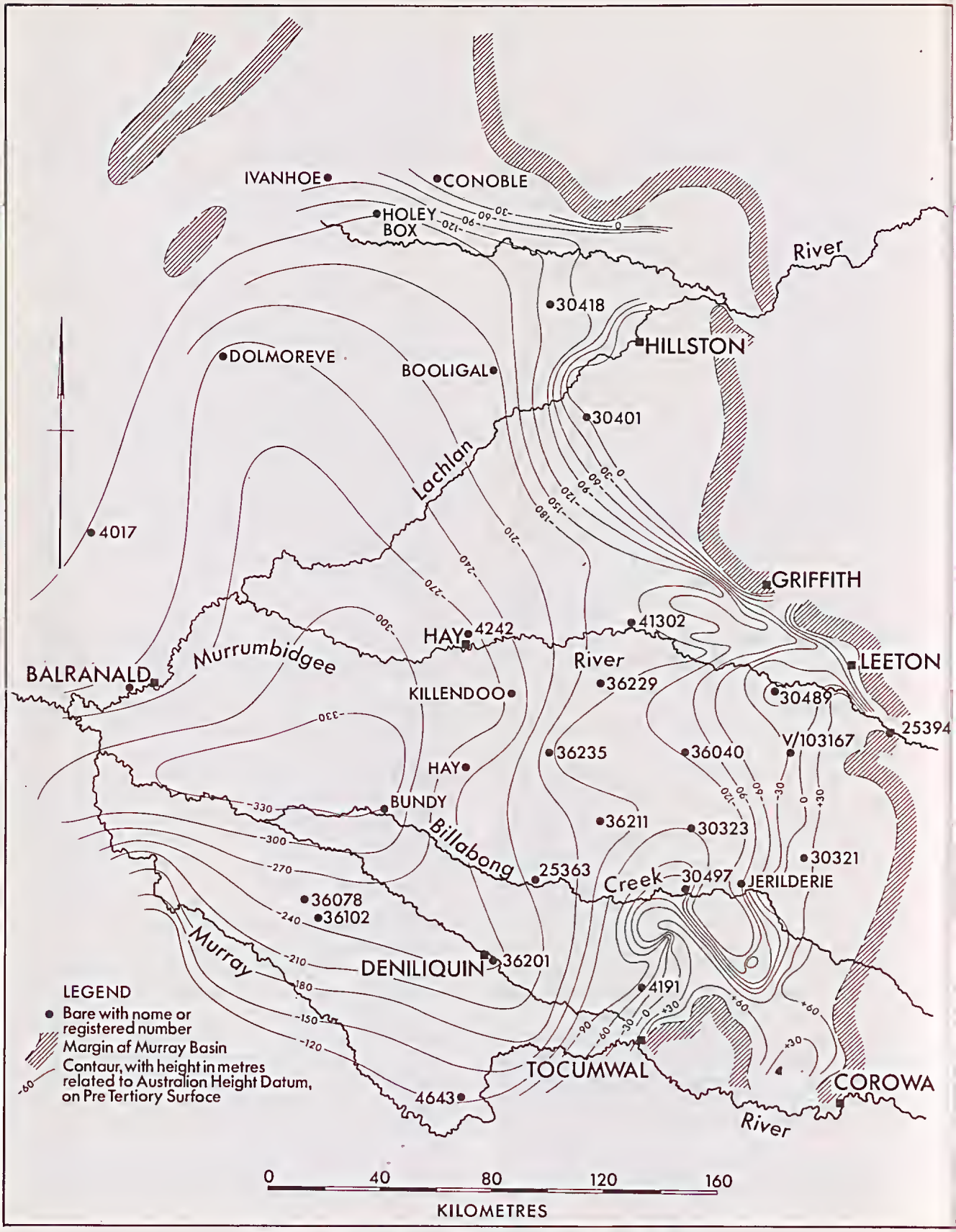
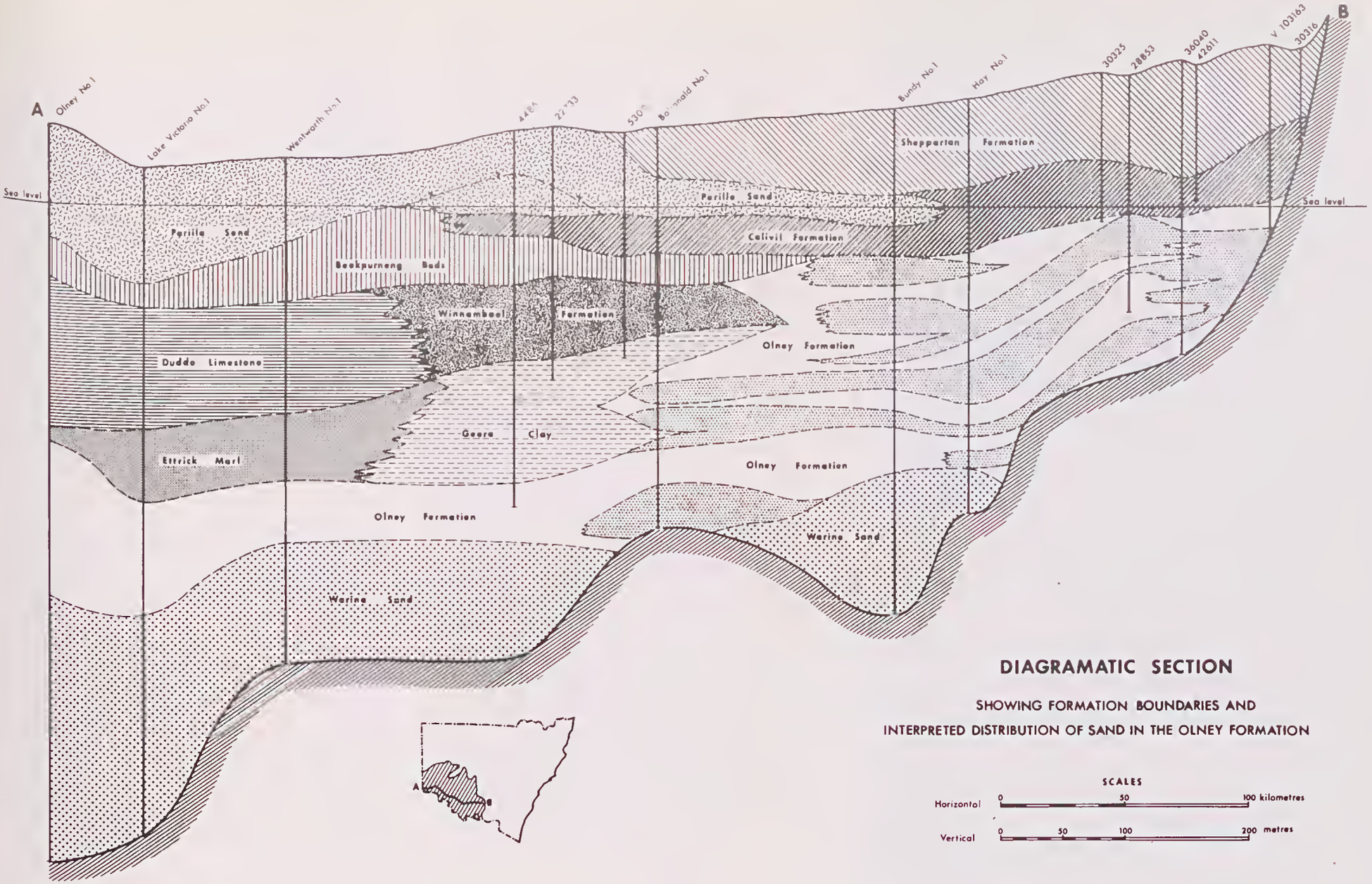


FIG. 1 — Contours on pre-Tertiary surface, Murray Basin.



DIAGRAMATIC SECTION

SHOWING FORMATION BOUNDARIES AND
INTERPRETED DISTRIBUTION OF SAND IN THE OLNEY FORMATION

SCALES

Horizontal 0 50 100 kilometres

Vertical 0 50 100 200 metres

FIG. 2